

Walking After Spinal Cord Injury Goal or Wish?

JAY V. SUBBARAO, MD, MS, *Hines, Illinois*

Less than a third of patients walk again after a spinal cord injury, whereas every one of them wants to try. Residual function, energy expenditure, the extent of orthotic support needed, and patient motivation will determine the outcome. Functional electrical stimulation and other new orthotic designs have not notably increased the number of persons able to walk after a spinal injury. Rehabilitation professionals can use patient education, illustrating relearning to walk with examples of infants' and toddlers' progress, to assist patients in understanding their abilities and limitations. The final decision on ambulation and orthotic prescriptions can be made in stages after a patient adjusts to a wheelchair-independent level.

(Subbarao JV: Walking after spinal cord injury—Goal or wish? *In Rehabilitation Medicine—Adding Life to Years* [Special Issue]. West J Med 1991 May; 154:612-614)

The incidence of traumatic spinal cord injury (SCI) is 7,000 to 10,000 cases each year, with a prevalence of 150,000 to 200,000.¹ The greatest number occurs in the age group 16 to 30 years,² although an increasing incidence of SCI is occurring in older persons.³ The survival after SCI has improved considerably because of better transportation techniques, efficient critical care, advances in technology, and improved urinary rehabilitation and respiratory management. The current ten-year survival rate of spinal cord injured patients is 86.3% of normal.²

Most SCI patients want to walk. This is important to them, and they repeatedly ask physicians, therapists, nurses, and other professionals about their chances of walking. The response to a question, "Can I walk?" should not be "yes" or "no" because there are few indicators that identify "walkers" from "nonwalkers." In this article I review the clinical criteria, psychosocial factors, and energy expenditures that should be considered in initiating a gait training program for SCI patients.

Clinical Factors Influencing Ambulatory Potential

The common clinical factors that influence a patient's walking potential after SCI are listed in Table 1.

Age

Chronologic age by itself is neither a positive nor a negative factor, but each patient's cardiopulmonary status and physical conditioning are important determinants.

Neurologic Level

The ratio of patients with quadriplegia to those with paraplegia is reported as 54:46.² Lesions below T-10 are associated with a higher residual functional level and a greater ability to walk. Associated injuries, a recent surgical procedure, and medical conditions affect a person's ambulatory potential. Even if a patient has residual motor function, the presence of contractures, pain, or uncontrolled spasticity will prevent walking.

Energy Expenditure

Many authors have studied the energy expenditures of paraplegic persons using different types of orthotics.⁴⁻⁷ Clinkingbeard and co-workers found that a person with paraplegia expends nine times more energy per meter than a normal person walking at a comfortable speed.⁸ The energy expenditure is influenced by the level of the lesion, the type of ambulation—four-point gait, swing-through gait, and so forth—walking speed, and distance traveled.

Psychosocial Factors

Most patients require assistance donning orthotic devices or direct assistance with walking itself. If the care giver is a spouse who already needs to assist in self-care activities,

TABLE 1.—Factors Influencing Walking Potential

Age
Level of injury
Complete
Incomplete
Associated injuries or operations, such as open reduction and internal fixation of long bone fractures or laminectomy and fusion
Medical conditions
Hypertension, diabetes mellitus, COPD
Cardiac disease
Complications, such as thrombophlebitis, pulmonary embolus, decubitus ulcers
Mechanical
Contractures
Heterotopic ossification
Pain
Uncontrolled spasticity
Kyphoscoliosis
Psychosocial
Degree of assistance available
Patient's level of participation or responsibility
Weight fluctuations
Family support
Drug or alcohol abuse
Associated head injury

COPD = chronic obstructive pulmonary disease

such as dressing and bladder and bowel care, these additional time demands may result in abandoning the use of orthoses. It is essential that the physician and the team have a good understanding of a patient's social and architectural environment.

Walking

Walking involves a translation of the body's center of gravity through a space in a *safe* manner along a pathway requiring the *least energy*. Daverat and associates found that 28% of their 157 SCI patients walked at the end of a year.⁹ Maynard and colleagues in a 1979 study of 123 patients noted that, of patients with incomplete sensory deficit 72 hours after injury, 47% were ambulatory and 87% of the patients with incomplete motor lesions were "walking."¹⁰

Stauffer divided ambulation into four categories¹¹:

- **Community walker:** Those patients who are able to get themselves out of a wheelchair or bed and walk for a reasonable distance in and out of their homes unassisted by another person. They may use crutches or braces and a wheelchair for exceptionally long distances.
- **Household walker:** Patients are able to walk within the home with relative independence but are unable to ambulate outside of the home for any significant distances and frequently use a wheelchair outside the home. Assistance may be required in getting out of bed or wheelchair.
- **Exercise category:** Functional mobility is attained with the use of a wheelchair. Patients require controlled conditions and considerable assistance to ambulate.
- **Nonambulatory:** Patients use a wheelchair entirely.

Such a classification should be used as a point of reference so that we can compare results between articles. Similarly, for the neurologic assessment, Frankel's classification is commonly used, which is as follows²:

- **A, Complete lesion:** complete loss of motor and sensory function below the lesion.
- **B, Incomplete—preserved sensation only:** preservation of any demonstrable sensation, excluding subjective phantom sensations; voluntary motor function is absent.
- **C, Incomplete—preserved motor (nonfunctional):** preservation of voluntary motor function, which performs no useful purpose except psychologically; sensory function may or may not be preserved.
- **D, Incomplete—preserved motor (functional):** preservation of voluntary motor function, which is useful functionally.
- **E, Complete recovery:** complete return of all motor and sensory function but still may have abnormal reflexes.

The term "incomplete lesion," although a good term for defining a neurologic deficit, is often misleading. Stover observed that 53.8% of the patients had incomplete lesions.³ A person with C-6 quadriplegia who has voluntary extension of a toe on one side is considered to have an "incomplete" neurologic lesion, but from a functional standpoint, the patient has a complete C-6 level injury. Rehabilitation professionals should document the muscle groups that are spared and that can be used.

Rehabilitation Training for Ambulation

Every SCI patient admitted for initial rehabilitation participates in intensive physical rehabilitation and patient education. Patients must be educated about the program and its

rationale. For example, patients should learn why they need to sit without arm support and the importance of this to future ambulation. All the patients are involved in a program aimed at improving trunk control, increasing sitting tolerance, strengthening the upper extremities, and retraining postural reflexes. In addition, other techniques to strengthen weaker muscles are used. The patient is advanced to standing at parallel bars with decreasing support at the trunk, pelvis, and knees. The patient starts ambulating in parallel bars with staff support and training orthoses. Patient performance at this stage is a critical indicator of future type and extent of orthotic supports and the patient's tolerance to ambulation.

Long-term Use of Orthoses

Mikelberg and Reid, in a five-year study, found that 50% of patients for whom orthoses were prescribed did not use them.¹² Only 5% of the patients routinely used their braces, and few walked. Rosman and Spira and Kaplan and associates similarly found a small percentage of patients using orthoses regularly.^{13,14} Recent advances in technology and newer designs are aimed at improving the acceptance of orthoses. Successful ambulation with decreased energy expenditure has been reported using the Craig-Scott orthosis,¹⁵ the Louisiana reciprocating gait orthosis,¹⁶ functional electrical stimulation,¹⁷ and a combination of orthosis and functional electrical stimulation.¹⁸ Long-term results need to be obtained in a sufficient number of patients, using these techniques, before it can be concluded that the number of patients who can walk after SCI has increased significantly.

Who Will Walk Again?

The preceding review of clinical factors, rehabilitative process, and literature regarding ambulation in SCI establishes the fact that only a small percentage of SCI patients can be trained to become successful walkers. Few objective criteria can be applied to predetermine the "winners." Our own experience and a review of the literature¹⁹ showed that patients became ambulatory only when they have good pelvic control, hip flexor strength of 3+, and quadriceps strength of at least 3+ on one side (muscle strength rated on a scale of 0 to 5). They also did not have contractures of the joints or uncontrolled spasticity. The patients able to walk required no more than one knee-ankle-foot orthosis and an ankle-foot orthosis on the other side. Waters and co-workers studied the determinants of gait performance in 36 SCI patients and described the ambulatory motor index derived from the manual muscle grade of both lower limbs.²⁰ They concluded that the ambulatory motor index influences the requirements for lower extremity orthoses and upper extremity assistive devices, that this index will determine the amount of arm work necessary as measured by the peak axial load, and that the combination of the ambulatory motor index and the peak axial load enables the potential of an SCI patient to walk to be determined clinically. Table 2 shows the neurologic deficit and type of ambulation possible. The final determinants of ambulation, however, are residual function, energy expenditure, a patient's tolerance to orthoses, the availability of a care giver, and a patient's motivation.

Is Walking a Realistic Goal or Desire?

Rehabilitation programs differ in their philosophies regarding offering trial ambulation and in prescribing orthotics. Only a small percentage of patients become ambula-

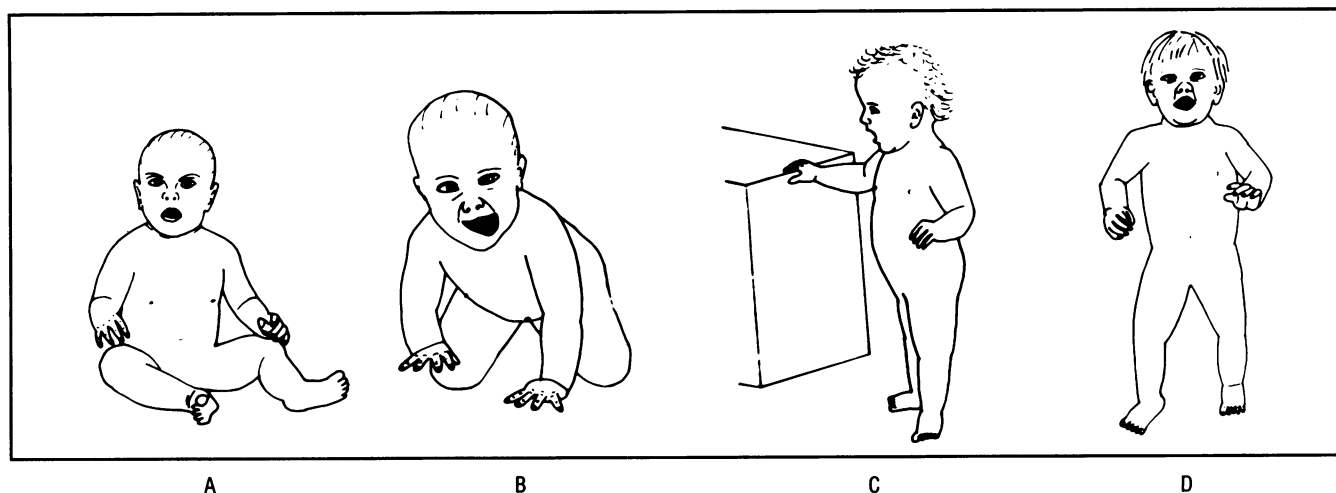


Figure 1.—The developmental sequences of an infant learning to walk are depicted: The child sits unsupported (A), crawls on all fours (B), stands with support (C), walks without assistance (D).

TABLE 2.—Spinal Segmental Levels and Type of Ambulation*

Neurologic Deficit Level	Type of Ambulation		
	Exercise	Household	Community
C-6 to C-7.....	yes	no	no
C-8 to T-1.....	yes	no	no
T-2 to T-10.....	yes	yes	yes/no
T-11 to L-2.....	yes	yes	yes
L-3 to L-4.....	yes	yes	yes
L-5 to S-1.....	yes	yes	yes

*In incomplete lesions, the type of ambulation is dependent on residual motor function.

tors, and most of those for whom orthotics are prescribed discard them soon after completing rehabilitation. Kaplan and colleagues found that the most common causes of rejecting the use of orthoses are excessive energy expenditure and the need for additional assistance to wear braces.¹⁴ In the present cost-control environment, it is difficult to justify the expense of orthoses and the weeks of trial ambulation training. It is preferable that patients with questionable ambulatory potential be discharged independent in wheelchairs with periodic reevaluations. By that time, a substantial number of patients will accept the fact that they are not capable of walking.

Although the rehabilitation team knows that only a small percentage of SCI patients will walk, the patients are often insistent that they can walk and want to prove that the professionals are wrong. The psychological consequences of standing and walking are "Getting out of bed and being back on my feet," a sign of recovery, and "Standing up and being able to look eye to eye," a sign of confidence.

How to Respond to the Question, 'Can I Walk?'

The question, "Can I walk?" is often a great challenge to physicians and therapists. Responding simply yes or no is unwise. The patient should be engaged in understanding the task of walking and its requirements. The staff can use the developmental sequences of infants and toddlers and ask the patient to recall that an infant first learns to sit with the support of arms, then without arm support, then crawls on all

fours, stands up by hanging on to objects, and eventually walks independently (Figure 1). This explanation matches the patient's rehabilitation program. It also enables the patient and staff to evaluate objectively the progress towards walking.

REFERENCES

- DeVivo MJ, Fine PR, Maetz HM, Stover SL: Prevalence of spinal cord injury: A reestimation employing life table techniques. *Arch Neurol* 1980; 37:707-708
- Stover SL (Ed): *Spinal Cord Injury: The Facts and Figures*. Birmingham, Ala, University of Alabama at Birmingham, 1986
- Subbarao JV: Spinal cord dysfunction in older patients—Rehabilitation outcomes. *J Am Paraplegia Soc* 1987; 10:30-35
- Chantraine A, Crielaard JM, Onkelinx A, Pirnay F: Energy expenditure of ambulation in paraplegics: Effects of long term use of bracing. *Paraplegia* 1984; 22:173-181
- Fisher SV, Gullickson G: Energy cost of ambulation in health and disability: A literature review. *Arch Phys Med Rehabil* 1978; 59:124-133
- Gordon EE, Vanderwalde H: Energy requirements in paraplegia ambulation. *Arch Phys Med Rehabil* 1956; 37:276-285
- Merkel KD, Miller NE, Westbrook PR, Merritt JL: Energy expenditure of paraplegic patients standing and walking with two knee-ankle-foot orthoses. *Arch Phys Med Rehabil* 1984; 65:121-124
- Clinkingbeard JR, Gersten JW, Hoehn D: Energy cost of ambulation in traumatic paraplegia. *Am J Phys Med Rehabil* 1964; 43:157-165
- Daverat P, Sibrac MC, Dartigues JF, et al: Early prognostic factors for walking in spinal cord injuries. *Paraplegia* 1988; 26:255-261
- Maynard FM, Reynolds GG, Fountain S, Wilmot C, Hamilton R: Neurological prognosis after traumatic quadriplegia—Three-year experience of California Regional Spinal Cord Injury Care System. *J Neurosurg* 1979; 50:611-616
- Stauffer ES: Orthotics for spinal cord injuries. *Clin Orthop* 1974; 102:92-99
- Mikelberg R, Reid S: Spinal cord lesions and lower extremity bracing—An overview and follow-up study. *Paraplegia* 1981; 19:379-385
- Rosman N, Spira E: Paraplegic use of walking braces: A survey. *Arch Phys Med Rehabil* 1974; 55:310-314
- Kaplan LI, Grynbaum BB, Rusk HA, Anastasia T, Gasster S: A reappraisal of braces and other mechanical aids in patients with spinal cord dysfunction: Results of a follow-up study. *Arch Phys Med Rehabil* 1966; 47:393-405
- Huang CT, Kuhlemeir KV, Moore NB, Fine PR: Energy cost of ambulation in paraplegic patients using Craig-Scott braces. *Arch Phys Med Rehabil* 1979; 60:595-600
- Phillips CA: Electrical muscle stimulation in combination with a reciprocating gait orthosis for ambulation by paraplegics. *J Biomed Engin* 1989; 11:338-344
- Jaeger RJ, Yarkony GM, Roth EJ: Rehabilitation technology for standing and walking after spinal cord injury. *Am J Phys Med Rehabil* 1989; 68:128-133
- Marsolais EB, Edwards BG: Energy costs of walking and standing with functional neuromuscular stimulation and long leg braces. *Arch Phys Med Rehabil* 1988; 69:243-249
- Hussey RW, Stauffer ES: Spinal cord injury: Requirements for ambulation. *Arch Phys Med Rehabil* 1973; 54:544-547
- Waters RL, Yakura JS, Adkins R, Barnes G: Determinants of gait performance following spinal cord injury. *Arch Phys Med Rehabil* 1989; 70:811-818